POTENTIATION OF CHANGES IN BRAIN ELECTRICAL ACTIVITY IN A CONSTANT MAGNETIC FIELD BY MEANS OF METRAZOL

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The effect of metrazol on changes in spontaneous and evoked electrical activity of the cerebral cortex, hypothalamus, and cerebellar cortex in a constant magnetic field (CMF) of intensity 500, 1000, and 4000 Oe was studied in experiments on rats. After preliminary injection of metrazol in a subconvulsant dose, the spontaneous rhythmic activity of the rats changes more sharply, the amplitude of the evoked potential increases considerably, and the number of additional phases in its structure rises. Potentiation of the effect of CMP by the analeptic action of metrazol points to the essential importance of the level of activation of the CNS in the response to the action of a magnetic field.

KEY WORDS: metrazol; evoked brain potential; constant magnetic field.

If an animal is placed in a constant magnetic field (CMF) of sufficiently high intensity, namely 500 to 1000 Oe or more, the spontaneous and evoked electrical activity of various brain structures is substantially modified. The character of the changes and the results of function tests suggest that during exposure to a CMF excitation processes predominate in structures of the central nervous system [3, 5]. The object of the present investigation was to study the possibility of modifying the effect of a CMF through a change in the functional state of the CNS.

EXPERIMENTAL METHOD

Evoked potentials (EP) were recorded from the sensomotor area of the cerebral cortex, the ventromedial zones of the hypothalamus, and the cortex of the anterior vermis of the cerebellum in 23 albino rats anesthetized with pentobarbital (40 mg/kg, intraperitoneally) before, during, and after whole-body exposure to a CMF with intensity of 500, 1000 and 3000 Oe. For unipolar recording of EP from the cortical areas silver electrodes were used, and from the hypothalamus electrodes made of manganin wire. The sciatic nerve was stimulated with square pulses 0.5 msec in duration, and of twice the threshold voltage. Metrazol was injected intraperitoneally in a dose of 20 mg/kg as a 1% solution, and the EP were recorded a second time 5-7 min after the injection, before and during exposure to the CMF. At each moment of the experiment 10 responses of the rat were recorded to pulses applied at intervals of 5 sec. During analysis of the results attention was paid to the shape and amplitude of the EP measured from spike to spike, and the mean value was calculated at each moment of recording for each rat.

The effect of metrazol (20-40 mg/kg) on spontaneous brain activity and its changes during exposure to a CMF of 4000 Oe was investigated in 13 rats. Some of these experiments were carried out on waking rats, wearing special coats to restrict movement noise. The electrocorticogram and hypothalamic electrical activity (by a unipolar method) and respiration were recorded on an electroencephalograph. A vertical CMF was created by the SP-15A electromagnet, in the gap of which, measuring 100 × 300 × 400 mm, the rat was placed (see [3]).

EXPERIMENTAL RESULTS

The analeptic effect of a subconvulsant dose of metrazol (20-30 mg/kg) was apparent in the rats 2-3 min after intraperitoneal injection. Restless movement and an increase in the frequency and depth of respiration were observed in the waking rats. Rats under superficial pentobarbital anesthesia were awakened by the injection of metrazol. No visible awakening was observed of deeply anesthetized animals, but changes in repiration and an increase in

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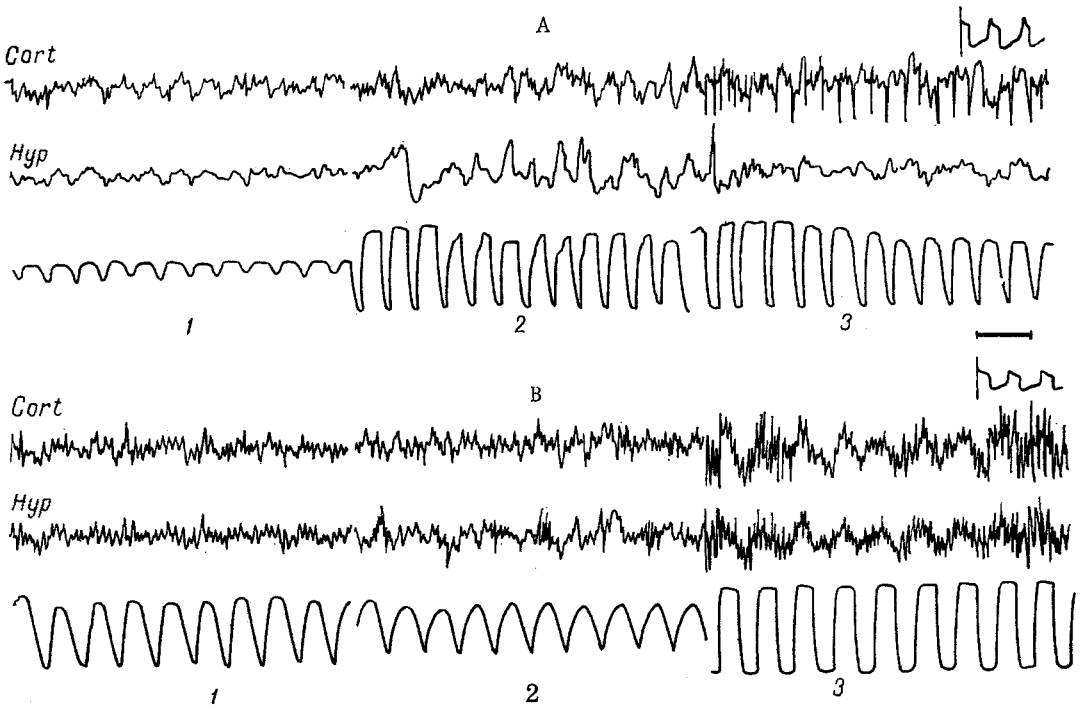

Fig. 1. Effect of metrazol on spontaneous cerebral cortical and hypothalamic electrical activity in anesthetized intact (A) and waking rats in a CMF of 4000 Oe (B). A: 1) before injection; 2) 3 min, and 3) 30 min after injection of metrazol (30 mg/kg): B: 1) before exposure to magnetic field; 2) CMF of 4000 Oe; 3) in CMF of 4000 Oe 5 min after injection of metrazol (30 mg/kh). Calibration: amplification 50 μV, time 1 sec.

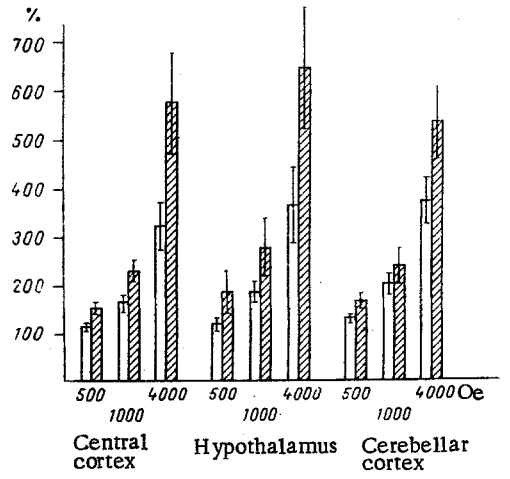

Fig. 2. Effect of CMF on evoked brain activity after injection of metrazol (20 mg/kg). Ordinate, increase in amplitude of EP (in % of initial value); abscissa, intensity of CMF, in Oe. Unshaded columns — before injection, shaded columns — after injection of metrazol.

sensitivity to external stimuli were observed and sleep became more superficial. External manifestations of the analeptic effect of metrazol were accompanied by characteristic changes in the background pattern of brain electrical activity [1, 2, 6, 7] which could be more marked in the cerebral cortex than in the hypothalamus (Fig. 1A). Changes in evoked electrical activity following administration of metrazol to rats anesthetized with pentobarbital were expressed more frequently as a decrease in amplitude of EP. On average the amplitude of EP in the cerebral cortex fell to 84.7 ± 5.7%, in the hypothalamus to 19.9 ± 2.2%, and in the cerebellar cortex to 91.4 ± 4.9% of the initial levels.

Against the background of the analeptic action of metrazol the effect of exposure to the CMF was noticeably potentiated as regards spontaneous and evoked brain electrical activity. In waking rabbits changes in the spontaneous activity during exposure to CMF of high intensity, as previous observations showed, consist of the appearance of bursts of synchronized high-volt-

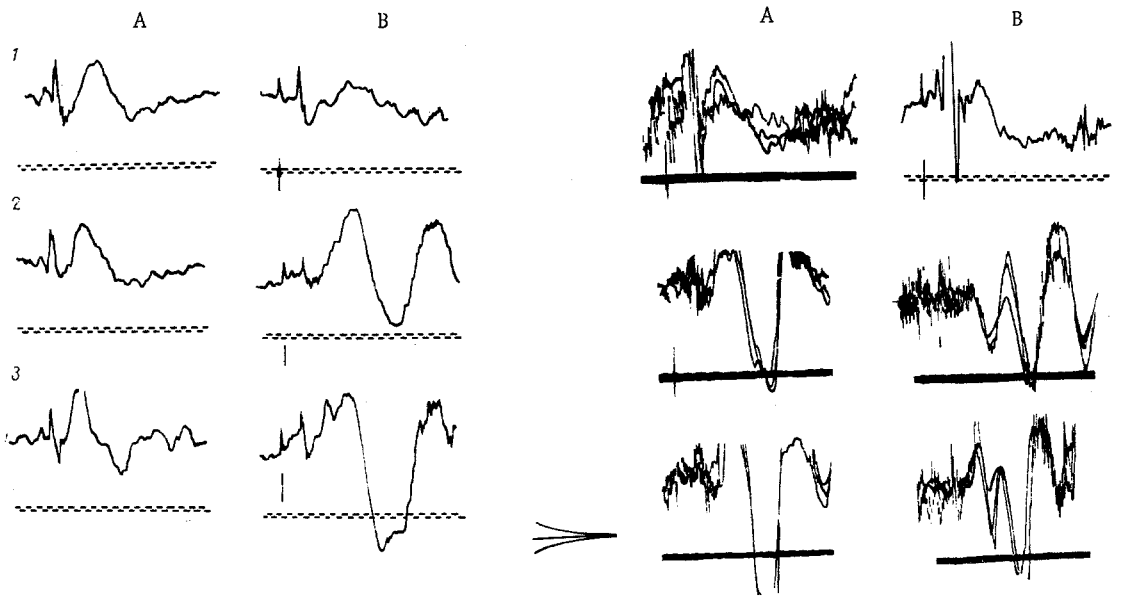

Fig. 3. Effect of metrazol on changes in cerebral cortical (left) and hypothalamic (right) EP in CMF. A) Before, B) after injection of metrazol (20 mg/kg); 1) before exposure to CMF, 2) in CMF of 500 Oe, 3) in CMF of 1000 Oe. Calibration: amplification 50 μV, time 10 msec.

age discharges on records obtained from different parts of the brain, and with an increase in the intensity of the field or in the case of animals with high individual sensitivity, these may change into regular activity, synchronized mainly with α-β_1 rhythms [5]. It will be clear from Fig. 1B that exposure of a waking rat to a CMF with intensity of 4000 Oe caused an increase in frequency of cerebral cortical potentials and the appearance of burts of synchronized discharges in the hypothalamus. After injection of metrazol (30 mg/kg) the fast activity recorded from both regions increased in amplitude and became more regular.

Changes in evoked activity in CMF have been described for the cerebral and cerebellar cortex of rats anesthetized with pentobarbital; they consist of an increase in amplitude of EP with the appearance of additional phases in its structure [3]. The present writers have also found similar changes in other parts of the brain, notably the hypothalamus. In CMF after preliminary injection of metrazol there was a more marked increase in the amplitude of EP in the part of the potential with highest voltage. This is clearly visible from the average data (Fig. 2) for all brain structures tested and in magnetic fields of three different intensities. For the cerebral cortex, moreover, potentiation of the effect of CMF, assessed by the degree of increase in amplitude of EP, was significant ($P < 0.05$). In all structures the effect of a CMF of 500 Oe after injection of metrazol became equal to the effect in a CMF of 1000 Oe on intact rats. Metrazol also potentiated the appearance of multiple-component potentials in CMF. The number of phases in the structure of EP increased on average in all three parts of the brain from 1.9 in the initial period to 2.5 in a CMF of 500 Oe; to 3.9 in 1000 Oe, and to 5.5 in 4000 Oe. In rats receiving preliminary metrazol, the corresponding figures were 1.9, 3.0, 4.8, and 6.7. In individual animals variations both of the effect of the CMF itself and also of its modification by metrazol were observed. In the experiment illustrated in Fig. 3, left, before injection of metrazol there were virtually no changes in the cerebellar cortical EP in a CMF of 500 Oe and the changes in a CMF of 1000 Oe were not sharply defined — merely an increase in the amplitude of EP and the appearance of a small additional negative phase. Injection of metrazol caused a decrease in amplitude of the original EP, but in a CMF of 500 and 1000 Oe it increased sharply, especially the amplitude of the additional slow wave. In another rat (Fig. 3, right) the hypothalamic evoked potential (lateral hypothalamic nucleus) showed no appreciable change after injection of metrazol, and changes in CMF were mainly expressed as an increase in the number of additional phases.

Preliminary injection of metrazol in subconvulsive doses thus caused marked potentiation of changes in electrical activity in the rat brain during exposure to a CMF. Evidence has also been obtained of potentiation of EEG changes in rabbits whose head is exposed to the

action of a CMF after administration of caffeine [4]. Potentiation of the effect of CMF against the background of the action of analeptics may evidently indicate the important role of the level of activation of the CMF in determining the susceptibility of animals to the action of the magnetic field.

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